technology opportunity

Peak-Seeking Technology for Real-Time Optimization of Complex Systems

Approach detects environmental changes in real time to adjust and improve performance

Innovators at NASA's Armstrong Flight Research Center have developed and are patenting a peak-seeking algorithm that can optimize the performance of complex systems in real time. Originally designed for aircraft flying in formation, the algorithm can automatically find optimal formation configurations to reduce aircraft drag and therefore increase fuel efficiency. The method is capable of using real-time measurements and quickly adapting to changing environmental conditions. In addition to aerospace applications, including commercial flight, this technology could also be used in situations where optimization is critical, such as in feedback control systems for manufacturing, business processes, energy management, and the automotive industry.

Benefits

- **Responsive:** Adjusts control in response to real-time environmental changes
- **Forward-thinking:** Considers the impact of noise and uncertainty in time-varying non-linear systems
- **Results-oriented:** Increases performance and fuel savings for flight applications; optimizes performance for other applications
- **Streamlined:** Allows for multi-dimensional optimization of processes simultaneously
- **Cost-effective:** Provides straightforward method that can be implemented for

Applications

Peak-seeking approaches find the most beneficial operating conditions in a variety of industries. This technology can be applied to numerous applications for real-time optimization, including some within:

- **Automotive** (e.g., speed and engine control, anti-lock braking systems)
- **Aerospace/Aeronautics**
- **Manufacturing**
- **Chemical**
- **Tissue and biochemical engineering** (e.g., bioreactors)
- **Petroleum**
- **Wind turbine**

Patents

Armstrong is seeking patent protection for this technology.

Commercial Opportunities

This technology is part of NASA's Innovative Partnerships Office, which seeks to transfer technology into and out of NASA to benefit the space program and U.S. industry. NASA invites companies to consider licensing its technologies for peak-seeking control (DRC-009-026, DRC-011-027, DRC-012-002) for commercial applications.

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Technology Details

This peak-seeking control technology was developed, in part, to help demonstrate autonomous control and drag reduction for aircraft flying in formation. Pilots can reduce drag and use up to 20 percent less fuel by placing a wingtip in the vortex of the leading airplane. However, manually keeping the plane in the most optimal position during a long flight can fatigue the pilot, as conditions continually change and adjustments are necessary. Armstrong researchers solved this problem by developing an adaptive peak-seeking algorithm that automatically determines optimal commands to place each aircraft in the most beneficial position by measuring and reacting to changing conditions in real time.

How It Works

Measuring multiple parameters in changing conditions—and responding to them appropriately—is difficult because the measurements are typically distorted by noise. Armstrong's technology addresses that problem by employing a time-varying Kalman filter. The filter is a recursive algorithm developed to estimate parameters within systems that are intrinsically random and uncertain. The Kalman filter is excellent at finding estimates when it encounters noisy signals. As a minimal-variant filter, it inherently produces the best estimates of a function with the smallest amount of variation from the true value. Thus, the filter is an ideal component of the peak-seeking algorithm as environmental conditions change.

In addition, this technology takes a multiple-input and multiple-output approach to design for all dimensions simultaneously. This contrasts with traditional peak-seeking architectures, which can only be designed by considering one dimension at a time, making the optimization effort difficult. Typical peak-seeking architectures also require known calibrated persistent excitation signals; the Armstrong method allows use of nearly any persistent excitation signal, allowing for greater simplicity and flexibility.

Why It Is Better

The Armstrong algorithm overcomes critical drawbacks of previous peak-seeking control methods, including more constricted techniques used in other industries and disciplines, such as manufacturing and automotive engineering. Armstrong's technology can optimize multi-dimensional processes and operations. In addition, it considers the effect of noise at the beginning of the algorithm cycle rather than correcting for it at the end. These advantages can simplify implementing a peak-seeking control system, improve the level of optimization, and broaden the range of applications for peak-seeking control.

Real-World Examples

Researchers at Armstrong Flight Research Center have applied and tested this algorithm in two additional applications. One application optimizes the lift-distribution for aircraft flying in formation, which increases the formation's performance. The other can help aircraft reduce drag and improve performance by optimizing the aircraft trim in real time.

For more information about this technology, please contact:

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